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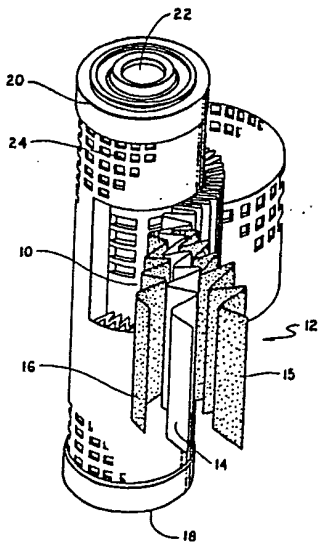
(54) All fluorocarbon filter element.

(57) A filter element constructed entirely of a fluorocarbon resin. The filter element includes a core member over which there is disposed a filter media, the end edges of which are bonded to a pair of end caps. An outer protective sleeve may be incorporated to protect the filter media from potential damage. The filter media includes a membrane and one or more screens which may or may not be laminated together.



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ALL FLUOROCARBON FILTER ELEMENT

BACKGROUND OF THE INVENTION

In many manufacturing processes it has been found desirable to utilize filter elements in the presence of highly reactive chemicals such as sulphuric acid, nitric acid, chromic acid, hydrochloric acid, hydrofluoric acid, sodium hypochlorite and the like, sometimes at relatively high temperatures. Such highly reactive chemicals attack most known prior art filter elements, particularly those utilizing solvents or adhesives in the manufacture of the elements. As a result, the prior art filter elements either cannot be used or have a relatively short lifetime due to chemical attack and must be replaced fairly frequently, thus adding to the cost of the manufacturing process.

Fluorocarbon resins have unique combinations of physical and chemical properties which make them particularly useful in such hostile environments as those of filtering reactive chemicals even at elevated temperatures.

Various efforts have been made to construct filter elements using fluorocarbon resins which will withstand such highly reactive chemicals and the best known art is represented by U.S. Patent 3,457,339,

2,732,031, 2,772,256, 2,934,791, 2,941,620, 3,013,607 and 4,284,966. However, to applicants' knowledge, the prior art has not been successful in constructing a filter element entirely of a fluorocarbon resin.

Fluorocarbon resins useful in the present invention include those polymers in which some or all external bonds of the carbon atoms have adhered thereto an atom of fluorine. Typical examples of such fluorocarbon resins are: a polymer such as that known as "PTFE" which consists of recurring tetrafluoroethylene monomer units whose formula is:

$$[CF_2-CF_2]$$

commonly referred to as "TFE"; a copolymer of ethylene and TFE known as "ETFE"; a copolymer of tetrafluoroethylene and hexafluoropropylene with the formula:

$$[CF(CF_3)-CF_2(CF_2-CF_2)_n]_m$$

commonly referred to as "FEP"; and a copolymer of tetrafluoroethylene and perfluoronated vinyl ether having the formula:

$$[CF(OR_f)-CF_2(CF_2-CF_2)_n]_m$$

commonly referred to as "PFA".

SUMMARY OF THE INVENTION

A filter element constructed exclusively of fluorocarbon resin which includes a fluorocarbon resin perforate core member having positioned thereover a fluorocarbon resin filter media including a fluorocarbon resin membrane. The end edges of the fluorocarbon resin filter media are closed and are bonded to a pair of fluorocarbon end caps.

The method of making a filter element of fluorocarbon resin which includes heat sealing the side and end edges of a filter media, pleating the filter media, filling the interstices between the pleats with a fluorocarbon material which is bonded to the filter media and thereafter heat bonding the end edges to the end caps of fluorocarbon material.

DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a composite isometric view, partially broken away, illustrating a filter element constructed in accordance with the principles of the present invention;

FIGURE 2 is a schematic diagram illustrating one of the steps in the manufacture of the filter element;

FIGURE 3 is a schematic diagram of a fragmented portion of the filter media after the step illustrated in FIGURE 2 has been performed;

FIGURES 4 and 5 illustrate a manner of seaming the side edge of a filter media constructed in accordance with the present invention;

FIGURE 6 is a schematic diagram of an additional step in the fabrication of a filter element constructed in accordance with the present invention; and

FIGURE 7 is a schematic diagram illustrating the bonding of an end cap to the closed end of the filter media.

DETAILED DESCRIPTION OF THE INVENTION

By utilization of a filter element constructed entirely of a fluorocarbon resin almost unlimited chemical resistance can be obtained from filter elements even in highly aggresive and hostile environments which normally limit the life of such filter elements. Such a filter element is illustrated in FIGURE 1 and is constructed in accordance with the principles of the present invention. As is therein shown a perforate support core 10 is constructed of a fluorocarbon resin and is utilized to support the filter media shown generally at 12. The filter media 12 is constructed of a filter membrane 14 which may be laminated with a support screen 16. As an alternative embodiment an additional support screen 15 may be placed on the opposite side of the membrane 14 to assist in handling the membrane during processing steps to form the pleated media. The membrane 14 is typically constructed of an expanded amorphous-locked fluorocarbon resin, such for example as a polytetrafluoroethylene, and may, for example, be of the type as disclosed in U.S. Patent 3,953,566 the disclosure of which is incorporated herein by reference. In any event the membrane fluorocarbon resin 14 is of uniform porosity and separates very small

particles from the filtrant and, for example, can have a rating of from .01 to 10 microns. On the other hand, the screen 16, as well as the screen 15 (if used), merely provide a mechanical support for the membrane 14 and have relatively large openings therein which do not inhibit the flow of the filtrant.

The filter media 12 is secured between a pair of end caps 18 and 20 one or both of which may have an opening such as shown at 22 to provide for the flow of the filtrant which typically flows from outside in as is well known to those skilled in the art. The filter media 12 must be firmly secured to the end caps 18 and 20 in such a manner that a fluid tight seal of high strength is obtained to prevent any bypass of the material being filtered. As is shown in FIGURE 1 the filter media 12 typically is pleated prior to being bonded to the end caps 18 and 20 but such is not required.

An outer protective sleeve 24 constructed of a perforate fluorocarbon resin is positioned over the filter media 12 to protect it from damage both from handling and also in the event a back pressure occurs from backflushing or an accidental surge or the like. If desired, the outer sleeve may be elminated.

The filter element as illustrated in FIGURE 1 is constructed entirely of fluorocarbon resin. As a result thereof, the filter element can withstand attacks by highly reactive chemical materials of the type above referred to.

One of the major difficulties encountered in attempting to construct a filter element of all fluorocarbon resins has been forming the longitudinal seam on the media 12 and sealing the end edges of the fluorocarbon

resin filter media 12. Applicants have found that by utilizing the material as above described and by choosing a screen material 16 (or a separate layer along the end edge) having a slightly lower melting point than the membrane material 14 and then by subjecting the end edges of the media 12 to appropriate heat and pressure of sufficient magnitude to melt selectively the end edge of the screen portion 16 it will flow through the pores of the membrane 14 and effectively encapsulate the same. Such is illustrated schematically in FIGURE 2 to which reference is hereby made.

Preferably the membrane 14 is constructed of a polytetrafluoroethylene fluorocarbon resin (PTFE) which has been laminated to a screen 16 constructed of tetrafluoroethylene and hexafluoropropylene fluorocarbon resins (FEP). By placing the end edge 26 of the media 12 between the surfaces of an anvil member 28 which is heated as is shown by the arrows 30 and by applying appropriate pressure as is illustrated by the arrow 32, the FEP melts and flows through the pores of the PTFE membrane as is shown in FIGURE 3 at 34. It has been found that if the temperature is maintained between 500°F and 650°F at a pressure of at least approximately 50 p.s.i. for a period of at least approximately 3 seconds, the appropriate melting and flow of the FEP material through the pores of the PTFE material occurs. Alternatively, a layer of FEP may be melted and caused to flow through the pores of the PTFE members as shown at 34 and then a screeen as shown at 16 may be applied.

As is well known to those skilled in the art and as above referred to, the filter media is appropriately pleated and an edge thereof is seamed which is further illustrated in FIGURES 4 and 5. As is shown, the edge

36 of the pleated media has been seamed to provide a seal along the entire length of the filter media. Through utilizing the technique as shown with regard to the end dges, particularly in FIGURES 2 and 3, it has been found that an appropriate seam which is totally sealed through the entire length of the filter may be accomplished. Alternatively, as is illusrated in FIGURE 5, the side edges 38 and 40 of the material may have an additional layer 42 of FEP material placed therebetween. This sandwich is then subjected to the heat and pressure at the temperatures and for the times above designated which will result in an appropriate fluid tight sealing of the seam formed when the pleated media is placed into a cylindrical form as shown in FIGURE 4.

After the appropriate heat sealing of the end edges and the seam as above described the pleated edges of the media are appropriately closed and thereafter secured and bonded to each of the end caps 18 and 20. Alternatively, the end caps may be bonded to the media simultaneously with the closing thereof.

By reference now to FIGURE 6, there is illusrated the manner by which the ends of the pleated fluorocarbon media are closed. As is therein shown a release agent 44 is applied to the recessed annular surface of a heated mold 46. An annulus 48 of FEP fluorocarbon material is placed within a space defined by the recessed annular mold 46. Thereafter the pleated filter media 12 disposed between the inner core 10 and outer guard 24 is placed in contact with the annulus 48. Heat is applied as shown by arrows 54 in an amount sufficient to melt the annulus 48 and part of the base of the mesh pack. A pressure as shown by arrow 56 is applied to the top of the filter

media assembly. The pressure may be applied during the entire heating step. The pressure along with the molten annulus causes the molten fluorocarbon material to flow between and close off the ends of the pleated media and to completely seal the same. Alternatively, the screen 16 may be extended beyond the end edge of the pleated media and such extension may be substituted for the annulus 48.

It has been found that the annulus 48 may take any form desired in that it may be a single or several layers, granular or powdered in form or a combination thereof. It has also been found that the annulus may be FEP or PFA fluorocarbon material. Furthermore, the end edges of the filter media may not require sealing as above described although such is considered the preferred embodiment.

The heat should be applied for a time and at a temperature to render the annulus 48 of FEP or PFA molten. It has been found that a temperature of from approximately 540°F to 650°F for a time of at least approximately 1 minute is sufficient. Also, a pressure of at least approximately one pound per square inch has been found preferable depending upon the time it is applied. Such has been found not to be critical with the main criteria being to insure that the annulus material totally encapsulates the membrane material to effect a complete seal of the end of the pleated media.

The release layer 44, if needed, may be any material that will not stick to the media or the retainer members. One such material is a thermoset polyimide sold under the name Kapton type H which is a trademark of E. I. duPont de Nemoirs & Co., Inc. Each end of the filter media is similarly treated to close it off. Subsequently

the end caps 18 and 20 are secured to the closed ends of the filter media.

For purposes of illustration an end cap 18 is shown in cross section in FIGURE 7 with the pleated filter media 12 treated as above described positioned in place thereon during the bonding of the end cap thereto as required for construction of a filter element in accordance with the present invention. The end cap 18 as is shown in FIGURE 7 is preferably constructed of FEP fluorocarbon resin material. The end cap is basically hat-shaped as is illustrated in FIGURE 7 and as also shown in FIGURE 1 may, if desired, have a centrally disposed opening as shown at 22.

The end cap 18 and the sealed end of the pleated filter media are each heated by application of energy thereto for a time and at a temperature sufficient to render the opposed surfaces thereof (as shown in FIGURE 7) molten. The opposed surfaces are then brought into contact and the molten material allowed to cool. In this manner the end cap fitting is fusion welded to the filter media to complete the filter element.

It will also be recognized by those skilled in the art and particularly with reference to FIGURE 1 that at the same time the filter media 12 is bonded to the end caps the support tube 10 and the protective sleeve 24 may also be bonded to the end caps in like manner. It will also, however, be recognized that there is no necessity for such bonding to occur since the support tube and the protective sleeve only provide a mechanical support and protection for the filter media 12 and need not be bonded. The only requirement is that the filter media 12

be securely and permanently bonded to the end caps to preclude any possibility of leakage of the material being filtered thereby contaminating the filtrant.

WHAT IS CLAIMED IS:

1. A filter element constructed exclusively from fluorocarbon resin comprising:

a fluorocarbon resin perforate support core member;

a fluorocarbon resin filter media including a porous membrane disposed upon said support core member and having first and second end edges; and

first and second fluorocarbon resin end caps heat bonded to said first and second end edges, respectively.

2. The filter element as defined in claim 1 wherein said filter media includes a plurality of layers of fluorocarbon resin material and wherein said end edges of said media are first heat sealed prior to heat bonding said end caps to said media.

3. The filter element as defined in claim 1 wherein said filter media is pleated and formed into a cylinder and contiguous edges thereof are first heat sealed prior to heat bonding said end caps to said media.

4. The filter element as defined in claim 1 which further includes an outer fluorocarbon resin perforate protective sleeve disposed over said filter media.

5. The filter element as defined in claim 4 wherein said inner support core and said protective sleeve are each heat bonded to each of said end caps.

6. The filter element as defined in claim 2 wherein said media includes a screen of fluorocarbon resin material laminated with said membrane fluorocarbon resin member.

7. The filter element as defined in claim 6 wherein said screen extends through pores in said membrane along said heat sealed end edges.

8. The filter element as defined in claim 6 wherein said filter media is pleated and wherein said media includes a membrane fluorocarbon resin member laminated with a screen of fluorocarbon resin material which is heat sealed along said end edges and along adjacent side edges so that a portion of said screen extends through pores in said membrane and effectively encapsulates said membrane along said heat sealed side and end edges.

9. The filter element as defined in claim 6 wherein said screen material has a melting point which is lower than the melting point of said membrane material.

10. The filter element as defined in claim 9 wherein a portion of said screen material exends through pores in said membrane material along said end edges thereof.

11. The filter element as defined in claim 10 wherein said end caps and said screen material are constructed of the same fluorocarbon.

12. The filter element as defined in claim 10 which is cylindrical in shape and which further includes a side edge which is heat sealed and wherein said screen material extends through pores in said membrane material.

13. The filter element as defined in claim 12 which further includes an additional layer of fluorocarbon resin material coterminus with said side edge and at least a portion of which extends through said pores of said membrane material, said additional layer being of the same material as said screen.

14. The method of manufacturing a filter element constructed exclusively of fluorocarbon resin and housing a filter media bonded at its opposite end edges to a pair of end caps, said media having a laminated screen and porus membrane, said method comprising the steps of:

applying heat and pressure to the end edges of said laminate filter media for a time and at a temperature sufficient to melt said screen and to allow said molten screen material to flow into the pores of said membrane;

applying heat to said end cap for a time and at a temperature sufficient to preferentially melt a surface of said fluorocarbon resin end cap;

inserting said end edges of said filter media into said end cap molten fluorocarbon material; and

cooling said end cap and end edges to solidify said molten material and bond said laminate filter media to said end cap.

15. The method as defined in claim 14 which further includes the steps of pleating said filter media forming said media into a cylinder, and applying heat and pressure to the contiguous side edges of said cylinder for a time and at a temperature to melt said screen and allow it to flow into pores in said membrane before bonding said media to said end caps.

16. The method as defined in claim 16 which further includes applying a separate layer of fluorocarbon material to said contiguous side edges prior to the application of heat and pressure thereto.

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FIG. 1

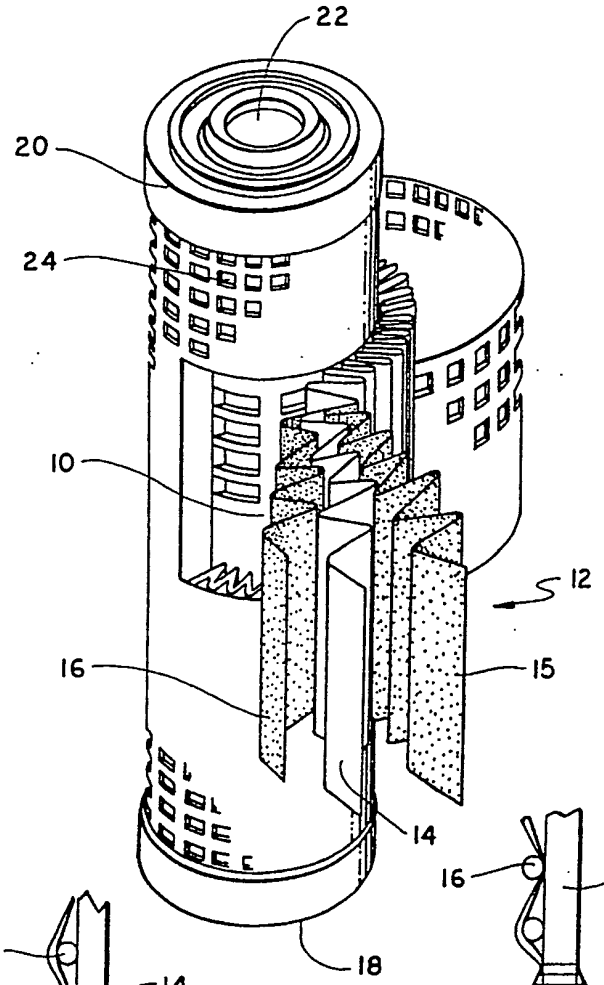
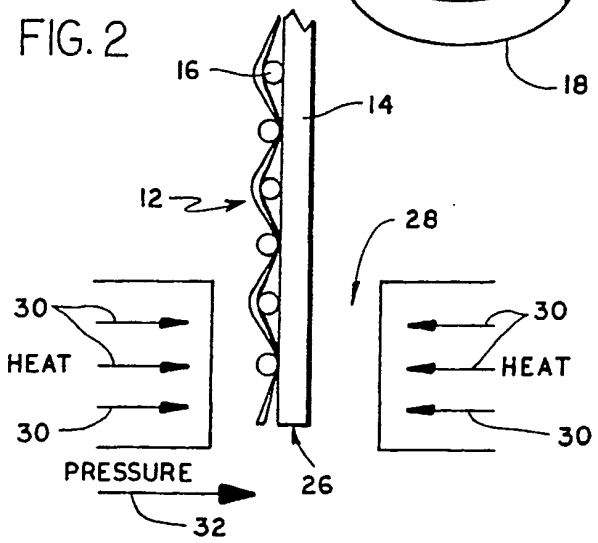


FIG. 2



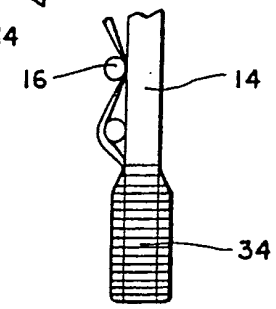


FIG. 3

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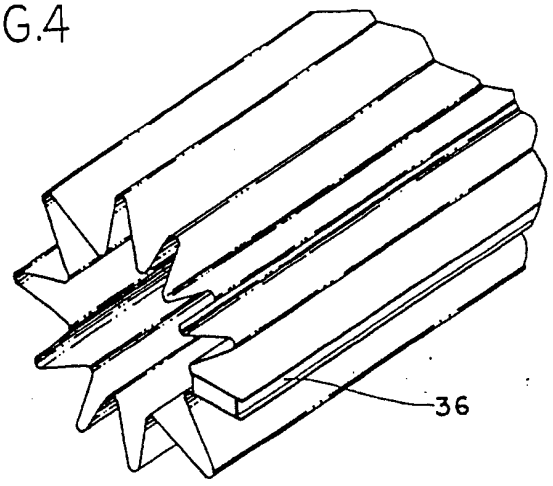
FIG.4



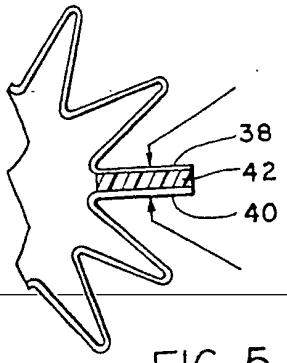


FIG. 5

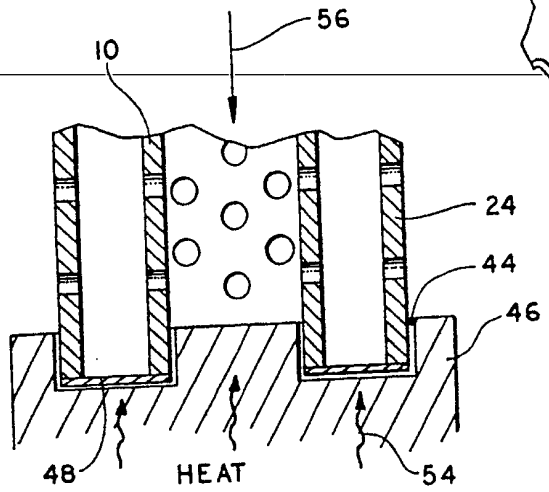


FIG.6

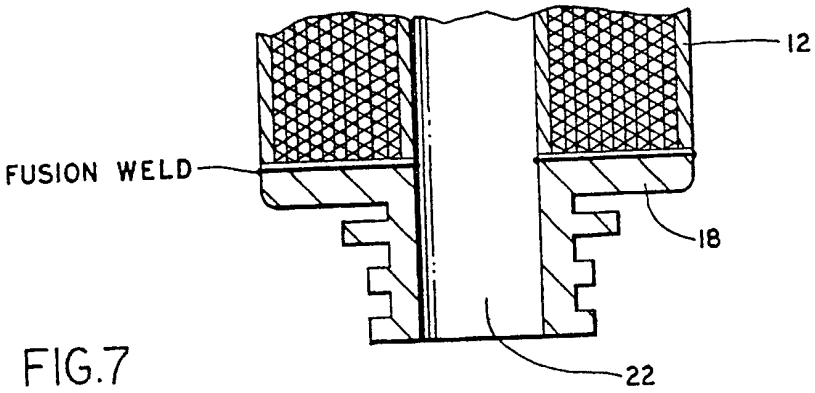


FIG.7